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Behavioural and psychological responses of the public during a major power outage: A literature review.

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Abstract

Widespread electrical power outages pose a serious risk to modern societies. During an outage, the behavioural and psychological responses of members of the public will influence the overall health, economic and social impacts. In this review, we identified 47 studies containing data relating to public reactions after a major loss of electricity. These highlighted eight key messages: 1) Preparing the public should reduce the impact of an outage; 2) Specific vulnerable groups including older adults and those with psychiatric or medical conditions will require targeted help to prepare; 3) Clear public health communications will be needed to reduce, for example, carbon monoxide or food poisoning; 4) The loss of communication infrastructure is likely to be an important stressor among the public; 5) Panic is unlikely; 6) Acts of altruism will, probably, outweigh acts of criminality; 7) The public's information needs will focus on 'what has happened' and 'when will power be restored';

Keywords

Blackout; electricity; power outage; community resilience; behavior; resilience

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Introduction

Widespread electrical power outages pose a serious risk to modern societies (Cabinet Office, 2017). Power outages can occur as discrete incidents resulting from technological malfunction or malicious action, or as a result of a precipitating disaster such as a storm or flood. Whatever their cause, the consequences can be severe. Pescaroli et al. (2017) identified multiple possible impacts ranging from those which pose a direct threat to health (e.g. increased traffic accidents, difficulties distributing medicines, loss of medical records, water shortages, spoilage of foods, public disorder) to indirect impacts (e.g. loss of financial services, reduced working hours, transport disruption, loss of communications) and operational challenges for government agencies (e.g. reduced ability of personnel to attend work, loss of communication between agencies, difficulties in procuring essential supplies).

Prolonged power outages are far from unheard of. For example, in 2017, Puerto Rico was left almost entirely without electrical power for several months following the devastation of Hurricane Maria. Post-incident reviews of this type of event tend to focus on the technical and organisational contributions to and impacts of power outages without going into detail about how the members of the community cope with, and respond to, the incident (e.g. Deverell, 2003; London Assembly, 2004). Similarly, although a growing literature exists around the concept of 'energy resilience' (e.g. Sharifi & Yamagata, 2016), where these papers discuss behaviour it is primarily in the context of shaping energy usage. While attempting to define 'community resilience' in the context of a disaster can lead one down an academic rabbit-hole (Patel et al, 2017), it is clear that how the public respond to almost any major incident plays a key role in determining its overall health, economic and social impacts. In this paper, we reviewed the literature in order to create an evidence-based picture of how the public are likely to respond to a major failure or threatened failure of electrical power, in terms of their behavioural or emotional state. The broad questions that we sought to address were: 1) What is the nature of public reactions to a widespread power failure? 2) Does the pattern of

reactions change over time? 3) How do reactions alter once power begins to be restored? 4) Do specific interventions or communications from government agencies or other actors (e.g. power companies) have any impact on public reactions?

Methods

Search strategy

We searched the following databases to identify potentially relevant literature: Ovid Medline; Books@Ovid; PsychINFO; Social Policy and Practice; Scopus; Web of Science; the collections database of the Cabinet Office's Emergency Planning College Library. We searched these databases for papers which included power failure terms (e.g. "power failure" or "blackout") and behaviour / psychology related terms (e.g. "behavior*" or "communicat*" or "social"). Searches were conducted in July 2018. A copy of the full search used for Ovid databases is given in Appendix One. We also asked colleagues within emergency preparedness groups to supply us with any literature relating to the topic that they were aware of, and searched the reference sections of included papers for additional citations.

Inclusion criteria

We included publications in our review if they: 1) were written in English; 2) related to either an actual incident involving a real or threatened widespread loss of electrical power (i.e. covering most or all of a given community), or else a hypothetical scenario concerning this type of incident; and 3) contained qualitative or quantitative data relating to behavioural, cognitive or emotional changes among the public during or after the power failure. Data could include self-report, observation or analysis of 'big data' (e.g. footfall data, political polling, hospital attendance records). We excluded observations that were not systematically collected such as anecdotal accounts or expert opinion. Although anecdotal accounts might be informative, we elected not to use them due to a desire to

impose a minimum quality criterion for data used in this review. Reports which were not peer-reviewed were eligible for inclusion.

Procedure and synthesis

We downloaded all citations identified from our searches and screened these based on their title and abstract for potential relevance. We retrieved and screened the full-text of documents that appeared relevant against our inclusion criteria. Database searching and application of inclusion criteria were conducted by one author, with any uncertainties resolved through discussion between both authors. We produced a table to provide details on the methods and main findings of each study that we identified. In our narrative summary, we broke the literature down according to the key outcomes that the papers discussed. We used a form of inductive thematic analysis to assist us in identifying a suitable structure for these outcomes. We grouped seemingly related outcomes together in an iterative process and attempted to provide overarching names for these groups, until we felt that a suitable structure had been achieved.

Results and discussion

Our databases searches retrieved 5,451 records. An additional 21 were identified from contact with colleagues or searching reference sections. Of these, 154 citations appeared potentially relevant. We were unable to locate the full text for 4 of these records. Of the remaining 150, we excluded 101 papers. Seventy-four of these were excluded on the basis that they did not include formal quantitative or qualitative data relating to public reactions. Because we located a systematic review which demonstrated an increase in carbon monoxide poisoning during power outages (reflecting a tendency for people to use generators or fuel-burning cooking equipment within their homes) we decided to also exclude two papers which focused exclusively on rates of carbon monoxide poisoning and which were already summarised in the systematic review. We also excluded one paper which examined the effects of planned rolling blackouts in Zambia, based on the limited relevance of this situation to the unplanned power outages which are the focus of this paper.

We included 49 papers, reporting data from 47 separate studies, including the carbon monoxide-related systematic review. A summary of each study is given in Annex B. The findings of these studies can be summarised as relating to preparedness, changes in daily routine, evacuation, information seeking, altruism and criminality, emotional impact, and potentially vulnerable groups.

Preparedness

Multiple studies emphasised that preparedness for a power outage is important, with preparedness encompassing both supplies and knowledge about how to use them effectively (e.g. Heidenstrom and Kvarnlof, 2018). In this context, supplies are not necessarily items purchased specifically with a power outage in mind. Possessing older, 'dormant' resources such as wood burning stoves or handpumps and remembering how to use them were identified as key coping strategies in studies of Finnish and Swedish households (Palm 2009; Rinkinen, 2013). For example, while 70% of respondents to one Dutch survey had taken some preparedness measures which helped them cope with a three-day power outage, most were not taken with a power outage in mind (Helsloot and

Beerens, 2009). Similarly, while most Ontario residents in one survey reported having potentially useful supplies, only 13% claimed to have an 'emergency preparedness kit' (Murphy 2004).

Research into why members of the public are often under-prepared for a power outage has identified a number of factors contributing to a lack of preparedness. One key barrier to preparedness is believing that a blackout is unlikely or not worth worrying about. Even in the wake of blackouts affecting England's two largest cities in 2003, only 44.8% of Brayley et al.'s (2005) UK survey respondents reported concerns about the possibility of future blackouts. This dropped to 36% among 18 to 25-year olds. Similarly, 85% of Dutch survey respondents who had not made any preparations for a power outage did not expect one to occur (Helsloot and Beerens, 2009), while key reasons for US survey respondents failing to prepare included not thinking about the risk and not believing a power outage is likely (Kosa et al., 2011, 2012, 2014).

In part, perceptions about the likelihood of an outage may themselves reflect the transactional nature of our relationship with power companies, which are underpinned by a general belief that payment for a constant supply should guarantee it (Brayley et al., 2005). This has led to low levels of acceptance that blackouts could happen or a reluctance to view them as a part of modern life, a view that is particularly common among those people who use electricity the most (Abrate et al., 2016). Kosa et al. (2011, 2012) also identified practical constraints such as not having enough room to store items, being concerned about the costs involved in preparing, a lack of knowledge about how to prepare and a sense that "nothing I could do to prepare would help." Similar reasons were cited by residents in Ontario for not assembling an emergency preparedness kit (Murphy, 2004), although Barata et al. (2004a) found households with children tended to be better prepared.

Although these barriers are problematic, prior experience has repeatedly been shown to improve preparedness. In the aftermath of a blackout, households often take time to reflect upon and improve their preparedness for a future event. In the Netherlands, 40% of those who felt unprepared for a major outage in 2007 reported taking steps to improve their future preparedness

(Helsloot and Beerens, 2009). Among older adults in the USA who had experienced a power outage, 76% subsequently made additional preparations (Kosa et al. 2012). Similarly, Barata et al. (2004b) reported that 49% of their survey respondents improved their preparedness after the extensive blackout in the Northeast USA in 2003. Even for households which already possess the correct materials, consideration is often given to ensuring that they are easily accessible, properly stored or used more effectively (Ghanem et al 2016; Heidenstrom and Kvarnlof, 2018). Prior experience also improves the knowledge people have for what actions to take during a blackout. People who have experienced a power outage are more aware of and confident in the correct actions to take, such as reducing the opening of fridges or freezers, disposing of spoiled food or filling the bathtub when the lights start to flicker. This has been observed in local communities in Norway, Sweden, Wales (Ghanem et al., 2016; Heidenstrom and Kvarnlof, 2018; Helsloot and Beerens, 2009; Kosa et al., 2012, 2014; Shreeves and O'Brien, 2013) and in large population surveys in the USA.

Attitude has also been linked to increased preparedness. In particular, a belief in self-sufficiency has been cited in a sample of US older adults as a key reason for their preparedness (Kosa et al., 2011, 2012), while in one Ontario survey (Murphy, 2004) most respondents agreed that "individuals / families should be most responsible for emergency preparedness". This sense of self-sufficiency may itself act as a form of emotional preparedness, helping people to cope during an outage (Rinkinen, 2013).

We identified almost no research looking at the effectiveness of communication campaigns in preparing the public for a power outage. However, Helsloot and Beerens (2009) found that only 3% of their sample of Dutch residents who experienced a power outage in 2007 cited a previous national preparedness campaign which included a focus on power outages as having influenced their preparedness activities (Helsloot and Beerens, 2009).

Changes in daily routine

One of the primary behavioural drivers during a winter blackout is the need to maintain warmth. This was a priority for Welsh households affected by a 36-hour loss of power during the winter of 2014, with adaptations including wearing more clothes, only warming one or two rooms, and using cooking stoves for warmth (Ghanem et al., 2016). The use of alternative means for heating or cooking hot meals during blackouts also shows up in health statistics. A systematic review of the health impact of power outages (Klinger et al., 2014) identified seven studies demonstrating an increase in carbon monoxide poisoning as people use generators or camping equipment in order to provide heat or power. Studies of USA populations indicate that these health statistics are fuelled by a lack of knowledge about carbon monoxide precautions, low awareness of carbon monoxide warnings and an absence of battery powered carbon monoxide alarms (Damon et al., 2013; Muscatiello, 2010).

Another key driver of behaviour during blackouts is the need for food and water. Food-related behaviours have been the topic of several studies, with poor food safety practices and loss of refrigeration being reflected in an increased number of calls to medical services relating to food poisoning, which have been noted to persist for several weeks after power is restored (Klein et al., 2007; Kosa et al., 2012, 2014). Marx et al. (2006) also noted increased presentations to emergency departments with diarrhoea, absenteeism due to gastrointestinal illness and purchasing of diarrhoea medications during and after blackouts.

A third key behaviour is a need to maintain contact with others. Ghanem et al. (2016) described how their Welsh respondents prioritised charging mobile phone batteries, especially for participants who were unable to use a landline telephone. Participants described charging their phones at work and swapping sim cards between phones to keep their connection (Ghanem et al., 2016). In other studies, participants have described losing telephone contact as ‘scary’ (Rinkinen 2013) or making repeated efforts to use mobile phones despite connection difficulties (Jennex, 2012).

A range of additional behaviour changes are also evident. Some, such as earlier bedtimes (Ghanem et al 2016; Heidenstrom and Kvarnlof, 2018; Mizuno and Okamoto-Mizuno, 2014) or heavier reliance on cars as opposed to public transport (Melnikov et al., 2015) have minimal health impacts. Others, such as attempting to remain at home without heating or siphoning petrol from cars to use in generators or elsewhere can lead to an increased number of deaths and injuries (Klein et al., 2007; Riddex and Dellgar, 2001).

Purchasing behaviour has not been particularly well studied, with only passing references made to the purchasing of food or camping equipment (Ghanem et al., 2016; Helsloot and Beerens, 2009). Other routine behaviours such as ability or willingness to attend work have received little attention, although one study of Dutch residents noted that 40% attempted to change their normal routines as little as possible during a power outage (Helsloot and Beerens, 2009).

One additional and rather contested behavioural change is also worth noting. Although no effect was observed among New Yorkers following their 1965 powercut (Udry, 1970; Izenman & Zabell, 1981), nine months after a major power loss in Zanzibar in 2008 an increased birth rate was observed (Burlando, 2014).

Evacuation

Evacuation was sparsely covered. Burger et al. (2017) found that among Hispanic or Latino patients who were receiving healthcare before Hurricane Sandy, an increased number of days without power was associated with an increased likelihood of evacuating from the area. Riddex and Dellgar (2001) reported that between 25%-56% of people evacuated their homes depending on the region during the 1998 Canadian ice storm. Most sheltered with friends or family, but 140,000 had to spend one night or more in shelters (Riddex and Dellgar, 2001). Finally, Eachempati et al. (2004) provided evidence of the public ability to evacuate calmly by noting that more than 1 million people

evacuated from New York metropolitan area subway tunnels, elevators and other facilities without a noticeable increase in health incidents during the 2003 blackout in the Northeastern United States and Canada.

Information-seeking

During a power outage, members of the public attempt to obtain information from multiple sources. Helsloot and Beerens's (2009) Dutch participants obtained information about an outage from neighbours (38%), the media (22%) and a dedicated disaster radio station (22%). A large number (26%) reported receiving no information. In a qualitative study of households affected by storms in Sweden, Palm (2009) noted that most used newspapers, the radio and their neighbours to obtain information. Few proactively contacted the power company. This differed in a Welsh community, where half of those interviewed reported having attempted to contact the power company (Ghanem et al., 2016). Similarly, a local power company reported answering over a million calls from customers, making 2 million calls and sending 1.4 million text messages in the wake of Hurricane Isaac in Louisiana (Miles et al., 2015).

Across multiple incidents, the key pieces of information requested by members of the public have been 'What has happened?' and 'When is the supply likely to return?' (Ghanem et al., 2016; Helsloot and Beerens, 2009; Palm, 2009; Paradis, 2012; Reuter, 2013). This information is needed to understand what steps to take (e.g. whether to start the emergency generator, what food to buy) and whether to evacuate. Additional information needs have included: information on health and safety issues (e.g. the safety of drinking water); where to evacuate to; where shelters are located; how to care for the elderly; how to deal with refrigerated medicine, spoiled food or electrical equipment; and whether job security is affected if transport to work is unavailable (Burger et al., 2013; Paradis, 2012). In a Dutch sample who felt let down by their local authority's blackout response, 53% requested multiple improvements in communication including more timely

information, better estimates of what was happening and how long it would take to resolve, door-to-door leaflets to ensure everyone received information, information on what citizens should do, and information targeted at people not living in communities (Helsloot and Beerens, 2009).

Several studies have provided information on levels of trust in different communicators. Trust in communications from a power company appears to be partly determined by their perceived level of knowledge about the situation. For example, in Sweden, workers on the ground were sometimes trusted more than call centre operators (Palm, 2009), while a preference to talk to a call operator instead of hearing a recorded message was expressed in Wales (Ghanem et al., 2016). Members of the public in Louisiana expressed confusion and frustration about different energy companies providing different customer updates (Miles et al., 2016). Finally, a key question asked about information given out in one trial of a power outage app was 'Who is providing the information?' (Reuter, 2013).

Altruism and criminality

In the short-term, blackouts often appear to bring-out positive aspects of humanity. The sociologist Chris Yuill documented "a heightened sense of being," with a "glorious," "wonderful," and "amazing… sense of community" in New York during the 2003 blackout (Yuill 2004), including "many acts of spontaneous humanity," such as sharing water or information, assisting people over barriers and members of the public taking on roles such as directing the flow of traffic. A notable lack of panic was identified here, and elsewhere (Helsloot and Beerens, 2009). In the short-term at least, alcohol and drug consumption may also decline, possibly explaining a decrease in calls to emergency medical services relating to these factors during the 2003 New York blackout (Freese et al., 2006).

The benefits of community interconnectedness have been identified in multiple case studies (Deverell, 2003; Ghanem et al., 2006; Heidenstrom and Kvarnlof, 2018; Palm, 2009; Riddex and Dellgar, 2001). Examples included neighbours feeling responsible for and looking after each other, checking on elderly relatives and helping them evacuate, and trusting community members to take

supplies from local stores on credit (Ghanem et al., 2016; Palm 2009). Within the Netherlands, approximately a third of Helsloot and Beerens's (2009) participants responded to a request from the Mayor for citizens to look after each other during a power outage. 38% reported that they had received support from other citizens, while 50% provided support to others. Within Ontario, 37% of one sample of residents reported providing assistance to others and 14% received assistance (Murphy, 2004). Increased altruism may also extend beyond the area affected by a blackout. During the Quebec blackout of 1998, appeals to other Canadians to reduce electricity consumption were successful, with reduced consumption correlating with television viewing, suggesting a possible impact of information about the blackout on altruistic acts (Lemieux, 2014). Charitable donations to help the victims of the disaster were also prevalent in Canada, especially in areas close to affected communities (Lemieux, 2014).

Criminality can also occur, however. On a minor level, the demand for generators during the 1998 Canadian blackout led to reports of generator thefts, although the overall crime rate declined (Riddex and Dellgar, 2001). Significant levels of criminality were evident during the New York blackout of 1977, however, with widespread looting and arson resulting in 2,931 arrests (Corwin and Miles, 1978). This looting was located mostly within areas already affected by higher levels of poverty (Muhlin, Cohen, Struening, Genevie, Kaplan and Peck, 1981; Wohlenberg, 1982). In New York in 2003, the number of calls to emergency medical services relating to gunshot wounds (but not other violent crimes) significantly increased (Freese et al., 2006). Crucially, though, levels of widespread criminality during a power outage appear to be rare – the absence of similar reports to those from 1977 New York for other power outages is notable. Also notable is a suggestion that government intervention might impact on levels and types of criminality during a blackout, as illustrated by the distribution of relief cheques to compensate for loss of revenue during the 1998 blackout in Quebec. The number of crimes against property were significantly reduced on days when cheques were distributed, although crime rates appeared to rebound on subsequent days (Lemieux, 2014).

Emotional impact

In the short term, positive emotional impacts related to blackouts have been reported in many case studies. This includes a positive sense of 'cosiness,' with factors such as quietness, candle-light, more family interaction, visiting friends more often, enforced time off work and earlier bedtimes making blackouts seem pleasant rather than intimidating (Ghanem et al., 2016; Heidenstrom and Kvernlof, 2018; Jennex, 2012; Murphy, 2004; Silvast, 2008). Such positive effects are less likely to be seen where people lack knowledge about the likely duration of the blackout; do not know if friends and family are safe; or have responsibility for vulnerable children, older adults or livestock (Heidenstrom and Kvarnlof, 2018). Preparedness and "blackout competence" may also help normalise the experience of a blackout, particularly when communities are able to adapt, rather than break, their everyday practices (Deverell, 2003; Heidenstrom and Kvarnlof, 2018) and when important needs, such as warmth and hot food, are met (Ghanem et al., 2016). The duration of a power outage is also likely to be important. While positive effects may be seen in the first few days of an incident, as time drags on, these are likely to wane. In his historical analysis of the 1947 Fuel Crisis in Britain, Farmer (2013) noted that the restrictions placed on leisure pursuits in an attempt conserve energy were the subject of negative reports in the mass media and contributed to a sapping of public morale and growing anger against the government. Aside from this, negative emotions have been poorly researched in the literature, although increased stress and inconvenience have been noted among a minority of residents of Ontario in one survey (17% and 12%, respectively) (Murphy, 2004).

Potentially vulnerable groups

A relatively large literature exists identifying potentially vulnerable groups who may display specific behavioural changes or experience an impact on psychological well-being during a blackout.

There is a possibility that power loss may exacerbate or trigger mental illness. Power failure in the wake of Hurricane Sandy was associated with increased numbers of people visiting local emergency departments for mental health related reasons after two to three days (Lin et al., 2016), while

Bromet et al. (2017) found that people with prior trauma exposure showed increased ratings of psychiatric symptoms when they subsequently experienced loss of power following Hurricane Sandy. Loss of services including electricity was associated with increased likelihood of post-traumatic stress disorder, worry and depression following Hurricane Ike, particularly in non-urban communities (Gros et al., 2012). Only one contrary finding has been reported, with Freese et al. (2006) noting a decrease in the number of calls to emergency medical services relating to emotionally disturbed patients in New York during the 2003 blackout. It is possible that this reflects the relatively short duration of that incident.

Older adults have also been examined as a potentially vulnerable group, though caution is needed in assuming vulnerability in this instance as older adults, who may have more experience in living with limited electrical supply, may have more knowledge and skills to draw on during a blackout (Ghanem et al., 2016; Rinkinen, 2013). However, Eachempati et al.'s (2004) review of hospital admissions to a New York city hospital during the 2003 blackout suggests a disproportionate number of falls within the elderly population. Similarly, Greenwald et al. (2004) identified a trend of older patients reporting to the emergency department during the USA and Canadian blackout of 2003.

Vulnerable sections of the population can also be identified by examining changes in the number of people attending hospital more broadly. Following Hurricane Sandy, although the Beth Israel Medical Centre serving lower Manhattan recorded an 11% decrease in the number of patients aged 18 to 64 years seen in the Emergency Department, there was a 48% increase for 65 to 79 year olds, and a 114% increase for those aged 80 or over (Gotanda et al., 2015). There were increased consultations relating to 'medication' (presumably relating to difficulties obtaining medication elsewhere or loss of refrigeration for some medicines), 'dialysis,' 'respiratory device' (presumably relating to problems using electrical medical equipment at home) and 'social complaints,' and, in those over 80ys, syncope. A reduction in the number of trauma or musculoskeletal conditions not

requiring admission was also observed, suggesting that patients with minor injuries stayed away from hospital during this period.

Patients who are reliant on electrical medical equipment at home are another vulnerable group during a power outage. For example, analysis of insurance data identified an increase in dialysis patients attending emergency departments following Hurricane Sandy (Kelman et al., 2015); children with respiratory difficulties attended hospital for treatment or evacuation during the Great East Japan earthquake, with only a minority being prepared with back-up generators or car adaptors (Nakayama et al., 2014); and medical device failure patients accounted for 22% of all admissions within a 24-hour period in New York following the 2003 blackout (Greenwald et al., 2004). Hospitals reported seeing many people who had 'power emergencies' rather than 'medical emergencies' and who were seeking to recharge medical equipment in Louisiana after Hurricane Isaac (Miles et al., 2016). Towards the end of the incident, libraries and Red Cross shelters began to be used to reduce the burden on hospitals by acting as 'electricity shelters' for such people. Reliance on electrical equipment may itself be partly a product of socio-economic status, with those who are more affluent being more likely to use (and suffer from the loss of) electric home aides and air conditioners to manage their health conditions (Lin et al., 2011).

Finally, one of the outcomes of the August 2003 blackout in the Northeastern USA and Canada was an impact on hospital discharges. City-wide traffic problems, electrical problems at patients' homes and more, precluded many discharges, creating an extra burden for the healthcare system (Eachempatic et al., 2004).

Conclusions

Although major power outages have previous affected many communities, the evidence-base regarding how people react to them is surprisingly limited. Relatively few studies have explored behaviour, communication or emotional impact in relation to an outage. Those that have often relied on small, opportunistic samples. There is a risk that participants in such studies are more likely to feel that they have an interesting story to tell than non-participants or to be more civic-minded, skewing the results. Therefore, our main recommendation is that additional, better quality research is needed. Of particular importance is the question of how best to encourage protective, adaptive responses before and during a major outage. The evidence we have reviewed provides several encouraging hints that this is possible and that, for example, official pleas for members of the public to support one another can promote helping behaviour (Helsloot & Beerens, 2009). However, it is also clear that official encouragement to prepare for future power outages can sometimes prove ineffective (Helsloot & Beerens, 2009). Identifying the key features of messages that improve public engagement with them would be of substantial benefit.

These points notwithstanding, some general conclusions can be drawn from the literature.

Preparing the public should reduce the impact of an outage

Findings from multiple studies suggest that people who have prepared for an emergency are less likely to feel intimidated by a power outage. With the right preparations in place and in the absence of caring responsibilities or other vulnerabilities, an outage may even have positive impacts on wellbeing. Even when people do not formally prepare for an emergency, many are likely to have access to essential supplies (Page et al., 2008). Knowledge about how best to use these supplies may be lacking, however. Attempts to prepare the public may therefore be most effective if they focus on what supplies are needed and how best to utilise existing resources. Consistent predictors of

preparedness in the literature were previous experience of an outage and perceiving that an outage could happen in the future. The need for message recipients to believe that a risk is likely before they will attend to a message is a core feature of many psychological theories of behaviour change (e.g. Rogers, 1983). Attempts to prepare the public may therefore have the greatest impact if they first emphasise the reality of the risk.

Clear public health communications will be needed

Multiple studies have identified health risks associated with power outages that could be reduced with effective communication designed to change behaviour. Public facing material about these health risks should ideally be developed and tested in advance. This information should be theoretically-based and address variables demonstrated to influence the effectiveness of risk communication across a variety of extreme events (e.g. Pearce et al., 2012; Rogers and Pearce, 2013).

Communication with others is a key need and potential stressor

Several studies identified communication between members of the public as a priority. This finding echoes previous research showing that the failure of the mobile communications network during disasters or terrorist attacks significantly adds to the stress experienced by members of the public (e.g. Rubin et al., 2005). During an outage, re-establishing the communications network as a priority should help to reduce levels of distress.

Policy makers should not focus on the potential for mass panic.

Although concerns about widespread panic are common among policy makers, disaster responders and the public (e.g. Nogami, 2018), we found no reports of panic in the literature. Indeed, authors have been at pains to point out the absence of panic across neighbourhoods or during evacuations from transport networks. This tallies with a broader literature on public responses to disasters, which finds panic to be notable by its absence (e.g. Sheppard et al., 2006). Instead it appears that

many people attempt to maintain a normal routine and report that adaptions to this routine, rather than major restructuring, helps to reduce any sense of threat.

Acts of altruism will, probably, outweigh acts of criminality and can be encouraged

Although instances of widespread criminality such as those in New York in 1977 are striking and memorable, they are also rare. Much more common are helpful interactions between neighbours, families and strangers. We identified some evidence that such interactions can be promoted by official interventions. Research to identify the best ways to promote and guide helping behaviours in the context of power outages (and other disasters) may be beneficial.

During a power outage, prioritise information about what has happened and when the supply will return

Multiple studies have identified the same key information needs among people affected by a power outage: 'What has happened?' and 'When will the supply return?'. The answer to the last question in particular is likely to shape people's behavioural responses. Inevitably, communication during a major outage will be difficult. However, ensuring that answers to these questions and advice on what to do reaches as many people as possible should help to reduce anxiety and encourage adaptive behaviours.

Helping potentially vulnerable groups to prepare should be a specific priority

Vulnerable groups are likely to include older adults, those with existing psychiatric disorder, and those reliant on electrically powered medical equipment. Increased help-seeking behaviour is likely among these groups. The factors contributing to vulnerability among these groups are likely to differ and include reliance on electricity to power medical devices, loss of refrigeration for medication, falls contributed to by lack of lighting, and reduced support being available as usual caregivers struggle with transportation. A specific emphasis on preparing such populations for a power outage may be beneficial.

Table one: Types of public reactions to outages, key patterns within the literature and implications

Type of reaction	Key patterns	Implications
Preparedness	• Possession of supplies and knowledge are beneficial • Barriers to preparedness include belief that power outage is unlikely • Prior experience of an outage and a sense of self-sufficiency lead to greater preparedness	Attempts to increase preparedness should address risk perceptions
Changes in daily routine	• Need for warmth is a key driver of behaviour changes, with a risk of carbon monoxide poisoning if heaters are used incorrectly • Poor food hygiene behaviours are likely, leading to increased gastrointestinal illness • Loss of communication is likely to be distressing • Other behaviour changes relate to attempts to adapt, rather than radically alter, existing routines	Public health messages are needed to reduce the health effects of some behaviours Restoring communication will reduce levels of distress
Evacuation	• Limited data suggest any evacuation is likely to be calm, and becomes more likely to occur as an outage continues	Policy makers should not focus on mass panic as a key concern
Information seeking	• Key information needs are "what has happened" and "when will power be restored" • Trust in information sources is partly determined by their perceived level of knowledge about the situation	Prioritise information about what has happened and when the supply will return
Altruism and criminality	• Panic is not reported in the literature • Reports of altruism and helping behaviours are common, and might be increased by official encouragement to help one another • Widespread criminality is rare	Policy makers should not focus on mass panic as a key concern Seeking ways to promote altruism may be beneficial
Emotional impact	• Power outages can trigger a sense of 'cosiness' • This is less likely for those with caring responsibilities, livestock, or poor preparedness. • Longer outages are more likely to induce anger	Attempts to increase preparedness are important
Potentially vulnerable groups	• Potentially vulnerable groups include older adults, those with mental illness and people reliant on electrically powered medical devices. • Risks include failure of medical devices, need for medication, falls, and reduced social support.	Helping potentially vulnerable groups prepare should be a priority

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Appendix A: Example search strategy used with Ovid databases.

1 power failure.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

2 power cut.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

3 power outage.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

4 electricity cut.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

5 electricity failure.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

6 electricity outage.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

7 blackout.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

8 1 or 2 or 3 or 4 or 5 or 6 or 7

9 behavior*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

10 behaviour*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

11 psych*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

12 decision.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

13 communicat*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

14 social.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

15 react*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

16 respon*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

17 communit*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

18 resilien*.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

19 critical infrastructure.mp. [mp=tx, bt, ti, ab, ot, nm, hw, fx, kf, px, rx, an, ui, ds, on, sy, tc, id, tm, pt]

20 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19

21 8 and 20

22 remove duplicates from 21

Appendix B: Summary of studies included in our review

First author and year	Incident	Participants	Method	Key findings
Abrate 2016	Hypothetical scenarios	Families of students in Italy (n=367)	Randomised presentation of multiple scenarios	Willingness to accept a blackout, in exchange for a discounted bill, associated with: having lower education; shorter duration blackouts (particularly among those with higher monthly bills); receiving a greater discount.
Barata 2004a Barata 2004b	Northeast Blackout, 2003 (New York)	Convenience sample of English speaking adults in the emergency department (n=414)	Prospective survey	Fifty-three percent of households with children compared with 46% of households without children reported changing their degree of preparedness after the blackout. Overall 49% of respondents reported changing their degree of preparedness
Brayley 2005	London Blackout and Birmingham Blackout, 2003	UK general public (n unknown)	Cross-sectional survey	Moderate levels of awareness and low levels of concern and acceptance that blackouts could occur, with variation between older and younger respondents. 65% were aware of the international series of blackouts in 2003. 60% remembered the UK blackouts. 44.8% reported concerns about the possibility of future blackouts. Younger respondents (18-25 years) expressed higher levels of awareness and lower levels of concern than the general population. General belief that if they pay for a constant supply they should receive it. Low levels of acceptance that blackouts could happen or that they should be accepted as a part of modern life. 81% believed that supply companies should be held responsible for loss of supply. Politicians were expected to accept some responsibility for the electricity supply but the onus was on the industry to provide a constant supply.

				Cross-generational differences exist with respect to the prioritisation of restoring electricity to the workplace or to the home.
Bromet 2017	Hurricane Sandy, 2012	Responders to the World Trade Centre 9/11 attack (n=870)	Cross-sectional study	Loss of power for more than 7 days was associated with increased odds of World Trade Centre-related PTSD (odds ratio 1.77 (95% confidence interval 1.12 to 2.81) and Major Depressive Disorder (odds ratio 1.58 (1.07 to 2.33).
Burger 2013	Hurricane Sandy, 2012	754 affected residents	Cross-sectional survey	During and after the storm, participants obtained information about their safety mainly from: TV (48.5%), radio (37.8%), friends (28.3%), the internet (22.5%).
Burger 2017	Hurricane Sandy, 2012	335 Hispanic / Latino patients receiving healthcare	Cross-sectional study, two to three years post-hurricane	Increased number of days without power was associated with increased self-rating of personal impact and increased likelihood of evacuating.
Burlando 2014	Month long blackout in Zanzibar, 2008	Population of affected and unaffected villages	Analysis of maternity ward records	A significant increase in birth rates was identified 8 to 10 months later among villages that lost electricity.
Corwin 1978	New York blackout, 1977	New York	Review of official data sources	Telephone exchange traffic increased by 300%. Calls to police increased by 500%. 2,931 arrests for looting (compared to 600 arrests for a normal 24hr period), 1,037 fires primarily a result of arson, 1,809 incidents of property damage as a result of looting or vandalism, 436 injuries to police officers.
Damon 2013	Storm related power outages in USA	32 people with experience of using generators during a power outage	Focus groups	Participants prepared by purchasing supplies, cooking meals in advance, filling bathtubs, obtaining fuel and testing their generator. Motivations for using a generator were to power heaters / air conditioners, and to keep fridges and freezers operational, though televisions, radios, water heaters etc also mentioned. Location of a generator was determined by: access to appliances, noise and exhaust, accessibility for refuelling and switching cords. Most would not operate it in the house, though use in enclosed spaces such as garages was mentioned. Knowledge

				of carbon monoxide and precautions was patchy: only half owned carbon monoxide alarms.
Deverell 2003	Kista Blackout in Stockholm, 2001.	General population	Evidence provided by stakeholders and organisations involved in the response.	Cultural diversity minimised the impact of the blackout. Some members of the public did not believe that a 33 hour blackout was a significant problem and had experience of similar incidents from their home countries. Additionally, some small businesses called on family members and friends to patrol their stores. This enabled the business to provide additional help whilst creating theft deterrence.
Eachempati 2004	Northeast Blackout, 2003 (New York)	Injured patients admitted to New York-Presbyterian Hospital.	Analysis of hospital records	New York: Unprecedented heavy pedestrian traffic combined with loss of streetlights and traffic signals. However, this did not impact the number of traffic-related trauma admissions. More than 1 million people were evacuated from subway tunnels, elevators, and other facilities without a noticeable increase in incidents. Experience of New York Weill Cornell Center: 'One half of the admissions represented elderly patients who had sustained a traumatic brain injury after falling in their homes.' City-wide traffic problems, electrical problems at patients' homes, and more, precluded many discharges.
Farmer 2013	British Fuel Crisis, 1947	English population	Analysis of media reports, mass observation diaries and other sources	Restrictions on leisure (BBC, newspapers, theatres, racing, etc) had a negative effect on morale and increased public anger.
Freese 2006	Northeast Blackout, 2003 (New York)	New York EMS callers	Analysis of EMS activity	Increase in EMS demand (7,844 incidents vs 3,860 expected). Significant decreases in psychological emergency calls and those related to drugs or alcohol.
Ghanem 2016	Storms in England and Wales, 2014	12 households in Wales	Qualitative interviews	Key concepts included preparedness, keeping warm, cooking meals, community resilience, knowledge from previous incidents and communication.
Gotanda 2015	Hurricane Sandy, 2012	Geriatric population of	Analysis of admissions data	Overall, there was a 20% increase in admissions. There was a decrease in emergency department attendance by 18 to 64yr olds

		Lower Manhattan	from Beth Israel Medical Centre	of 11%, an increase of 48% in 65 to 79yr olds, and an increase of 114% in 80yr+. There appeared to be a decrease in minor, but increase in major, trauma or musculoskeletal complaints. There were increases for medication, dialysis, respiratory device and social complaints, and, in over 80ys, syncope.
Greenwald 2004	Northeast Blackout, 2003 (New York)	Patients presenting with medical device failure in an Emergency Department.	Analysis of medical records.	23 of 255 patients coming to the ED during the 24-hour period presented with medical device failure. 13 patients were admitted and accounted for 22% of all admissions within the 24-hour period. Mean age of 67 years.
Gros 2012	Hurricane Ike, Texas, 2008	Adult population	Cross-sectional survey (n=1,249)	Loss of services, including electricity, was associated with increased likelihood of post-traumatic stress disorder, depression and worry. The relationship was stronger in participants from non-urban communities.
Heidenstrom 2018	Storms and fire in Norway and Sweden, 2011 and 2013	14 rural households	Qualitative interviews	Prior experience influences knowledge of what to do and what resources to keep. Community interconnectedness adds to resilience. Having leisure supplies (e.g. camping equipment) and knowing how to use them aids resilience. Negative emotional impact reduced, and positive impact enhanced, by adapting rather than breaking everyday routines, by knowing likely duration of blackout and that friends and family are safe, and by not being responsible for vulnerable people or livestock. After blackouts, people reflect on how to respond better next time.
Helsloot 2009	Bommeler and Tielerwaard, Netherlands, 2007	221 residents of the affected areas	Cross-sectional survey	60% did not know in advance what to do in a power outage. 40% knew what to do during the incident. Of those who claimed to know what to do, this was based on “own information” (60%), previous experience (23%), information from media (22%), and professional experience (10%). A previous national preparedness campaign was cited by 3%.

				70% had taken some preparedness measures that were largely not taken in preparedness for a power outage but that proved helpful (e.g. candles, torches, batteries). Of those with no preparedness, 85% did not expect a power outage to occur. Information about the situation was obtained via: neighbours (44.8%), the media (21.3%), a disaster radio station (15.4%). No information was received by 17.6%. Information during the outage was obtained from neighbours (38%), the media (22%) and a disaster radio station (22%). No information was received by 26%. 40% attempted to carry on with life as normal, 25% went looking for more information, “a few” bought more food and no-one panicked. Over half of the participants (54%) said that the information they received did not meet their requirements, with the key information need being the duration of the outage. 38% received support from other citizens. 50% provided support to others.
Izenman 1981	New York Blackout 1965	New York	Analysis of birth data	Analysis of six years of birth records finds no obvious impact of the blackout on conception rates.
Jennex 2012	San Diego blackout, 2012	Students (n=370)	Cross-sectional survey	Participants attempted to: update Facebook (39.7%); use cell phone to make a call (93.5%); receive a call (80.8%); send a text message (90.2%); receive a text message (87.7%); access the internet (69.8%). Most attempted social media access every few minutes (25.3%) or hourly (33.9%) and attempted to reach 1 to 10 people (95.4%).

Kelman 2015	Hurricane Sandy, 2012	Patients with end-stage renal disease	Analysis of claims data from the Centers for Medicare and Medicaid Services (CMS) Datalink Project	4.1% of Sandy group had an emergency department visit, compared to 2.6% and 1.7% in non-Sandy affected control groups.
Klein 2007	Northeast Blackout, 2003 (USA)	Review of calls to poison control centre	Analysis of existing medical database	Significant increase in calls, particularly relating to: gasoline exposure, carbon monoxide exposure, food poisoning or spoilage, safety of water. Increased food enquiries persisted for two weeks after the blackout.
Kosa 2011 & Kosa 2012	Hypothetical future power outage	Random sample of 1,011 US residents. A subset of 290 of the respondents aged 60yrs or over was analysed separately.	Cross-sectional survey	**Results for full sample** *Experiences during a previous outage:* 30% had experienced a 24hr or longer power outage before. 23% were very prepared for it, 56% somewhat prepared, 21% not at all prepared. Key behaviours during the outage were: keeping fridge and freezer shut as much as possible (83.4%), discarding perishable foods (31.3%), discarding thawed frozen food (37.1%), cooking and eating perishable foods as soon as possible (43.2%). Range of methods used to check whether food was safe, including considering temperature of fridge (72.3%) or freezer (59.8%) and tasting the food (28.5% to 19.6%). 66% subsequently purchased supplies to prepare for a future power outage. *Preparations for a future outage:* 14.6% reported being "fully prepared". 39.3% had taken no special steps to being prepared. Reasons for preparedness included "experiencing extended power outage or other emergency before" (43.1%) and "believe it is important to be self-sufficient" (32.0%). Key reasons for not preparing: have not thought about it enough (44.2%), not believing a power outage is likely (22.2%), not having enough room to store items (20.3%), a sense that "nothing I could do to prepare would help" (7.2%), not knowing how to prepare (10.6%) and that it would cost too much money to prepare (15.8%).

				Proportions who had heard the following advice: keep fridge and freezer doors closed as much as possible (96.3%), do not eat perishable food after four hours without power (32.8%), discard thawed food in freezer (59.5%), never taste food to determine safety (84.5%). **Results for older adults** *Experiences during a previous outage:* 25% had experienced a 24hr or longer power outage before. 36% were very prepared for it, 49% somewhat prepared, 15% not at all prepared. Key behaviours during the outage were: keeping fridge and freezer shut as much as possible (77.1%), discarding perishable foods (37.8%), discarding thawed frozen food (36.6%), cooking and eating perishable foods as soon as possible (35.2%). Range of methods used to check whether food was safe, including considering temperature of fridge (74.2%) or freezer (72.4%) and tasting the food (36.3% to 20.7%). 76% subsequently purchased supplies to prepare for a future power outage. *Preparations for a future outage:* 17% reported being "fully prepared". 34.4% had taken no special steps to being prepared. Reasons for preparedness included "experiencing extended power outage or other emergency before" (51.3%) and "believe it is important to be self-sufficient" (32.6%). Key reasons for not preparing: have not thought about it enough (41.8%), not believing a power outage is likely (26.7%), not having enough room to store items (19.0%), a sense that "nothing I could do to prepare would help" (11.0%), not knowing how to prepare (8.2%) and that it would cost too much money to prepare (8.1%). Proportions who had heard the following advice: keep fridge and freezer doors closed as much as possible (97.1%), do not eat

				perishable food after four hours without power (33.9%), discard thawed food in freezer (73.3%), never taste food to determine safety (87.0%)
Kosa 2014	Hypothetical future power outage	Random sample of 502 US residents with previous experience of a power outage	Cross-sectional survey	16% very prepared for the power outage, 46% somewhat prepared, 22% not very prepared, 16% not at all prepared. Older people were more prepared. 45% and 34% believed it would be very likely or somewhat likely that eating refrigerated foods after 24 hours, or foods in the freezer after 48hrs, could cause illness. Key behaviours during the outage were: keeping fridge and freezer shut as much as possible (78.6%), discarding perishable foods (34.7%), discarding thawed frozen food (36.6%), cooking and eating perishable foods as soon as possible (43.5%), putting food in coolers with ice packs (34.3%), using a generator (21.6%). Range of methods used to check whether food was safe, including considering temperature of fridge (69.7%) or freezer (69.4%) and tasting the food (34.7% to 26.7%). *Preparations for a future outage* 25% reported being "very prepared," 43% somewhat prepared, 23% not very prepared, 8% not at all prepared. Reasons for preparedness included "experiencing extended power outage or other emergency before" (62.2%) and "believe it is important to be self-sufficient" (23.7%). Key reasons for not preparing: have not thought about it enough (27.4%), not believing a power outage is likely (12.1%), not having enough room to store items (21.0%), a sense that "nothing I could do to prepare would help" (6.6%), not knowing how to prepare (3.8%) and that it would cost too much money to prepare (25.2%).

Lemieux 2014	Freezing rain storm in Quebec, 1998	Canadian population	Analysis of crime rate data, electricity consumption (in unaffected regions of Canada) and donations of money	Crimes against property decreased on days when relief cheques where distributed to affected citizens. Television viewing was associated with reduced electricity consumption in response to appeals from power companies in unaffected regions of Canada. Unaffected areas that were closer to the affected region tended to give more in terms of financial donations. Greater donations were associated with greater television viewing and lower than expected criminality in the communities involved.
Lin 2011	Northeast Blackout, 2003 (New York)	All residents of NYC.	Analysis of medical records.	This study found increased susceptibility among the elderly (those ≥75 years of age) during the blackout. Specifically, admissions due to chronic bronchitis were eight times the rate on normal days. This increase in admissions for chronic bronchitis could be linked to the larger proportion of the elderly with this disease who were more susceptible to heat during the August 2003 blackout. High sociodemographic (SES) groups such as white people, non-Hispanic people, and those living in higher income areas had a significantly increased risk of admission for respiratory diseases during the blackout. Higher SES groups are more likely to use nebulizers or other electric home aids and air conditioners than lower SES groups in summer. Thus, they depend on electric equipment to manage disease and are adapted to living in cooler conditions, making them more susceptible to heat during a power outage.
Lin 2016	Hurricane Sandy, 2012	Population of Southern New York State	Analysis of New York State Department of Health data on daily emergency	Higher rates of ED visits in two regions (Bronx and Queen's) were associated with higher percentage of households without power.

			department visits for mental health reasons.	
Marx 2005	Northeast Blackout, 2003 (New York)	New York Emergency Department patients	Analysis of syndromic surveillance data	Visits to ED for diarrhoea increased to 117 (vs 63 expected). Increases in anti-diarrhoea medication and electrolyte sales noted in pharmacies, increase in number and proportion of worker absences due to gastrointestinal illness. Two thirds of patients interviewed had heard messages about avoiding spoiled foods – a similar proportion to control patients.
Melnikov 2015	North Holland power outage, 2015	Amsterdam drivers	Analysis of road sensor data	A higher traffic volume was observed in affected areas, together with a reduction in speed of 40%, as people used their cars instead of the affected public transport systems.
Miles 2016	Hurricane Isaac, Louisiana 2012	33 politicians, emergency planners, power company employees	Qualitative interviews	Communication frustrations included not being able to access energy company websites, and not knowing whether information from one energy company applied to all. Hospitals reported that many people seeking admittance had "power emergencies," requiring electricity to recharge their medical devices. Libraries and Red Cross shelters were used as "electricity shelters" to support such people.
Mizuno 2014	Great East Japan Earthquake, 2011	Eight elderly people living in Sendai	Prospective study	Actigraphically assessed time in bed decreased on the night of the earthquake, but then increased as a result of earlier bedtimes until power was restored.
Muhlin 1981	New York Blackout, 1977	New York	Analysis of existing socioeconomic data and data on looting	Geographic areas with greater looting were associated with higher proportions of rental housing and black ethnicity, and by fewer vacant units, fewer bars or liquor stores and fewer large families.
Murphy 2004	Northeast Blackout, 2003 (Ontario)	1,203 residents of Ontario	Cross-sectional survey	Most respondents have emergency preparedness materials (e.g. over 80% have a torch), but few have these assembled as a discrete emergency preparedness "kit" (13%). Key reasons for not assembling a kit were: it is not important, it will not be needed, it

				had not occurred to them, they knew where the individual items were. 38% would like more information on emergency preparedness. Most agreed that "individuals / families should be most responsible for emergency preparedness." Main impacts included: financial loss (30%); increased stress (~17%); visiting friends and family (~14%); feeling vulnerable (~13%); inconvenience (12%). Virtually none reported any increase in violence or vandalism. 89% felt it somewhat or very likely that neighbours would help in a time of crisis, more so in rural areas. 37% provided assistance during the blackout (including checking on safety, cooking and babysitting, providing supplies etc) and 14% received assistance.
Muscatiello 2010	Snowstorm, Buffalo USA, 2006,	101 people from households where a member was diagnosed with carbon monoxide poisoning during the outage	Cross-sectional survey	64.9% of households had operated a generator in an enclosed space. 49.5% had come across a warning about carbon monoxide before or during the outage. 46.0% of households had a carbon monoxide alarm with primary or back-up battery power. An alarm sounded in 24% of households.
Nakayama 2014	Great East Japan Earthquake, 2011	24 paediatric patients admitted to hospital and 31 parents of patients with ventilators or oxygen equipment at home	Cross-sectional questionnaire study and review of medical records	Sixteen patients attended hospital due to electrical shortage affecting their medical equipment. Only 10 / 31 patients at home could have stayed at home because of sufficient oxygen backup or owning car power adaptors or power generators.

Palm 2009	Storms in Sweden, 2005 and 2007	Interviews with 15 households, 15 municipal administrators and four politicians, and survey responses from 62 households	Qualitative interviews and cross-sectional survey	Biggest problems for respondents were non-functioning freezers, toilets, heating, water and lack of light. Lack of information was cited as a problem, particularly what has happened and when it will be fixed. Trust in the electricity company was influenced by their understanding of the local situation for the customer. Workers on the ground were trusted more than the central company. Respondents perceive municipalities to be responsible for healthcare, school and taking care of citizens, but care of the elderly to be the responsibility of households. Most households used radio, newspaper and neighbours to get information. Most did not proactively contact the power company.
Paradis 2012	Northeast Blackout, 2003 (Toronto)	Population of Toronto	Account of experience of 2-1-1 healthline.	Increase in call volume of 300%. Initial questions: what is the cause, where is affected, are stores open, is transit system working. Reassurance needed by callers. Anecdotal evidence that providing up-to-date news about services and the current situation reduced the strain for the 911 service. Health and safety concerns for senior and disabled (especially those 'trapped' in high-rises) grew more prominent with time. Questions about refrigerated medication, spoiled food, electrical medical equipment and worries about job security if they could travel to work were also prominent.
Reuter 2013	Hypothetical power outage	12 German adults	Qualitative appraisal of communication app	The key information need was why the incident had occurred and how long it would go on for. Participants also wanted to know: how they could offer help, phone numbers to use to obtain more information, and who was providing the information.
Riddex 2001	Canadian ice storm, 1998.	'Those involved'	Non-structured interviews with 'those involved'.	Hospitals coped well, overall, in spite of a significant increase in the number of individuals attending the emergency department. Pre-hospital services also experienced a notable increase in the number of non-emergency responses required. They were used to provide transportation, equipment and supplies. This included an increase in the transport of home care patients who needed to be taken to hospital. Information sharing was severely limited. This

				led to the distribution of inaccurate information and creation of rumours. Behaviour change examples include: • Evacuation: between 25%-56% of people leaving their homes depending on the region. • Use of generators or alternate fuel sources: increased number of individuals with carbon monoxide poisoning, • Attempts to clear ice: increases in the number of deaths and injuries from individuals attempting to remove ice sheets from buildings (e.g. roofs). • Failure to evacuate: 6 individuals died from hypothermia after remaining in houses without heating.
Rinkinen 2013	Heavy snow in Finland, 2011	6 households in detached houses and 8 local business or government actors	Qualitative interviews	Participants variously 'embraced' the disruption or felt scared by the isolation. Availability of, and knowledge of how to use, 'dormant' resources improved resilience. Older adults can have more knowledge about how to cope and a different attitude towards power outages.
Shreeves 2013	Tornado, Madison County, 2011	10 residents	Qualitative interviews	Residents relied heavily on peers and local radio in making decisions. Prior experience of disasters also influenced decision making.
Silvast 2008	Power loss in Helsinki, Finland	Nine households (qualitative interviews) and 115 people (survey responses)	Qualitative interviews and cross-sectional survey	Sense of relaxation is possible, particularly for blackouts with natural causes. Participants felt they could last the following number of days without using: Fridge (1), Toilet (2), Warm water (3), Lights (6), Computer (10). Participants were prepared with: Candles and matches (100%), flashlight and batteries (98%), battery operated radio (80%), utility phone number (66%), fireplace (56%).
Udry 1970	New York blackout, 1965	Adult population	Analysis of birth records	No increase in birth rate was seen nine months following the blackout.

Wohlenberg 1982	New York blackout, 1977	New York	Records on location of criminal damage and local economic status	“Fifty-one percent of the variation in number of looted stores in a zone could be accounted for by the variation in number of poor persons residing in that zone.”
Yuill 2004	Northeast Blackout, 2003 (New York)	N/A	Structured walk through New York by a sociologist	Key findings were: a) a heightened sense of being (heightened sense of connection and conviviality); b) a lack of panic; c) keeping things in the city ticking over (e.g. directing traffic) and d) offering mutual aid.